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Technical Report

STUDY OF IONOSPHERIC ABSORPTION DURING A SOLAR ECLIPSE

Part I: Solar Eclipse

N. Carrara, P. F. Checcacci, M. T. de Giorgio

CENTRO DI STUDIO PER LA FISICA DELLE MICROONDE
CONSIGLIO NAZIONALE DELLE RICERCHE
FIRENZE - ITALIA

January - 1962

The research reported in this document has been sponsored in part by ELECTRONICS RESEARCH DIRECTORATE, AIR FORCE CAMBRIDGE RESEARCH LABORATORIES of the AIR RESEARCH AND DEVELOPMENT COMMAND, UNITED STATES AIR FORCE, through its European Office.

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S U M M A R Y

A program of measurements of cosmic noise absorption by the ionosphere was developed in Florence. The purpose of this investigation was to observe the absorption variation during the solar eclipse of 15 February 1961. A description of the employed equipment is made. The obtained results are presented too.

IONOSPHERIC ABSORPTION DURING A SOLAR ECLIPSE

1 - Introduction

During the solar eclipse of 15 February 1961 a program of measurements of the cosmic noise absorption by the ionosphere was developed at Centro Microonde. The main purpose was to observe the variation of the absorption due to the eclipse itself ([1]).

To this end the cosmic noise level on 27.6 MHz was recorded during the eclipse day and on control days before and after the eclipse day. The measurements were carried out by using two riometers and one radiometer operating on 27.6 MHz.

In addition two other radiometers, operating on 40 MHz and on 108 MHz respectively, were used to monitoring the cosmic noise level on these frequencies.

It was also planned to survey the ionospheric absorption during a complete year. To this aim a riometer is continuously running since February 1961 and will run until March 1962.

This work was performed under the Contract AF 61(052)-498.
The purpose of the present report is to describe the experimental equipment used during the eclipse and the results of these investigations.

2 - Ionospheric Absorption

2.1 - General Remarks

It is well known that an electromagnetic wave crossing an ionized medium turns out to be attenuated according to the law

$$E_1 = E_0 \exp \left\{ - \int_0^z K(z)\,dz \right\} \qquad (1)$$

where E_0 is the initial amplitude of the electric field of the wave, E_1 the amplitude of the electric field at the point specified by the distance z measured along the direction of propagation and $K(z)$ the attenuation per unity field, per unity path lenght.

In the case of longitudinal ionospheric propagation, that is in the case when the earth's magnetic field $\underline{H}$ is parallel to the direction of propagation, one has in the MKSQ system

(2) $$K(z) = \frac{N(z)e^2}{2e\varepsilon_o m}\,\frac{1}{n_1(z)}\,\frac{\nu(z)}{\nu^2(z) + \left[\omega \pm \omega_g(z)\right]^2}$$

where

$N(z)$ is the electronic density along the direction of propagation

e '' the electron charge

m '' the electron mass

ε_o '' the free-space dielectric constant

c '' the free-space light velocity

n_1 '' the real part of the refractive index

$\nu(z)$ '' the angular collision frequency along the direction of propagation

$\omega_g(z)$ '' the angular gyromagnetic frequency along the direction of propagation

ω '' the angular frequency of the wave.

When the angular frequency of the wave is large with respect to the critical frequency ω_o of the crossed layers n_1 is $\simeq 1$ (2) and the non-deviative absorption occurs. By putting $n_1 = 1$ Eq. (2) becomes

(3) $$K = k\,\frac{N(z)\,\nu(z)}{\nu(z)^2 + \left[\omega \pm \omega_g(z)\right]^2}$$

where k is a constant.

According to APPLETON and PIGGOTT (2), we will assume relation (3) to be valid in the case of vertical propagation at our latitudes. Then, being z equal to the heigth h over the ground, on can rewrite Eq. (1) as

(4) $$E_1 = E_o \exp\left\{-k\int_0^h \frac{N(h)\nu(h)}{\nu^2(h) + \left[\omega \pm \omega_g(h)\right]^2}\,dh\right\}$$

If $\omega \gg \nu$ and $\omega \gg \omega_g$, one can assume that as a first approximation the denominator equals ω^2, consequently it is not function of the height. In this case relation (4) becomes

$$E_1 = E_0 \exp\left\{-\frac{k}{\omega^2}\int_0^h N(h)\nu(h)\,dh\right\} \tag{4a}$$

and consequently

$$\int_0^h N(h)\nu(h)\,dh = \frac{\omega^2}{k}\ln\frac{E_0}{E_1}$$

which can be evaluated by measuring E_1 and E_0.

Since the absorption is a function of the electron density and of the collision frequency, the absorption variation may be caused by a variation of the values of both these parameters as well as by a variation of their general behavior as a function of the height.

The ionospheric region which is responsible for the main part of the absorption is the lower part of the ionosphere due to the existing high values of the collision frequency. However recent investigations show that a not negligible contribution to the whole absorption arises from the high portion of the ionosphere, where the electron density reachs the maximum ([3]). On the other hand up to date there are no informations about the eventual contribution of the exosphere to the total absorption.

2.2 - Absorption Measurements

The method we used consists in measuring the cosmic

noise power received by an antenna at the ground as a function of the time. Of course this method allows one to measure the attenuation of the ionosphere as a whole [3], [4].

The cosmic noise power received at the ground depends on the antenna features on the equivalent temperature of the sky above the antenna and on the ionospheric absorption.

Let us consider the sketch of Fig. 1 in which the axes of the reference system are oriented toward the zenith and the north of the observer, respectively. Let us denote by $A(\theta,\varphi)$ the effective aperture of the antenna and by $B(\theta,\varphi,T)$ the brightness of the sky on given frequency.

This brightness is a function of the angles θ and φ but it is also a function of the sidereal time T due to the earth's rotation.

The power available at a receiver having a bandwidth B_W is

$$(5) \qquad P_u(T) = \frac{1}{2} B_W \iint_{beam} B(\theta,\varphi,T)\, A(\theta,\varphi)\, d\Omega$$

where $P_u(T)$ indicates the power which will be received without ionosphere by taking into account that the noise power received by a linear polarized antenna is one half of the incident power [5].

Let us assume a plane uniformly stratified ionosphere above the antenna (Fig. 2). By recalling Eq. (4a) the received power P becomes

$$(6) \qquad P(T,t) = \frac{1}{2} B_W \iint_{beam} B(\theta,\varphi,T)\, A(\theta,\varphi)\, e^{-2\sec\theta\, k_1 D(t)}\, d\Omega$$

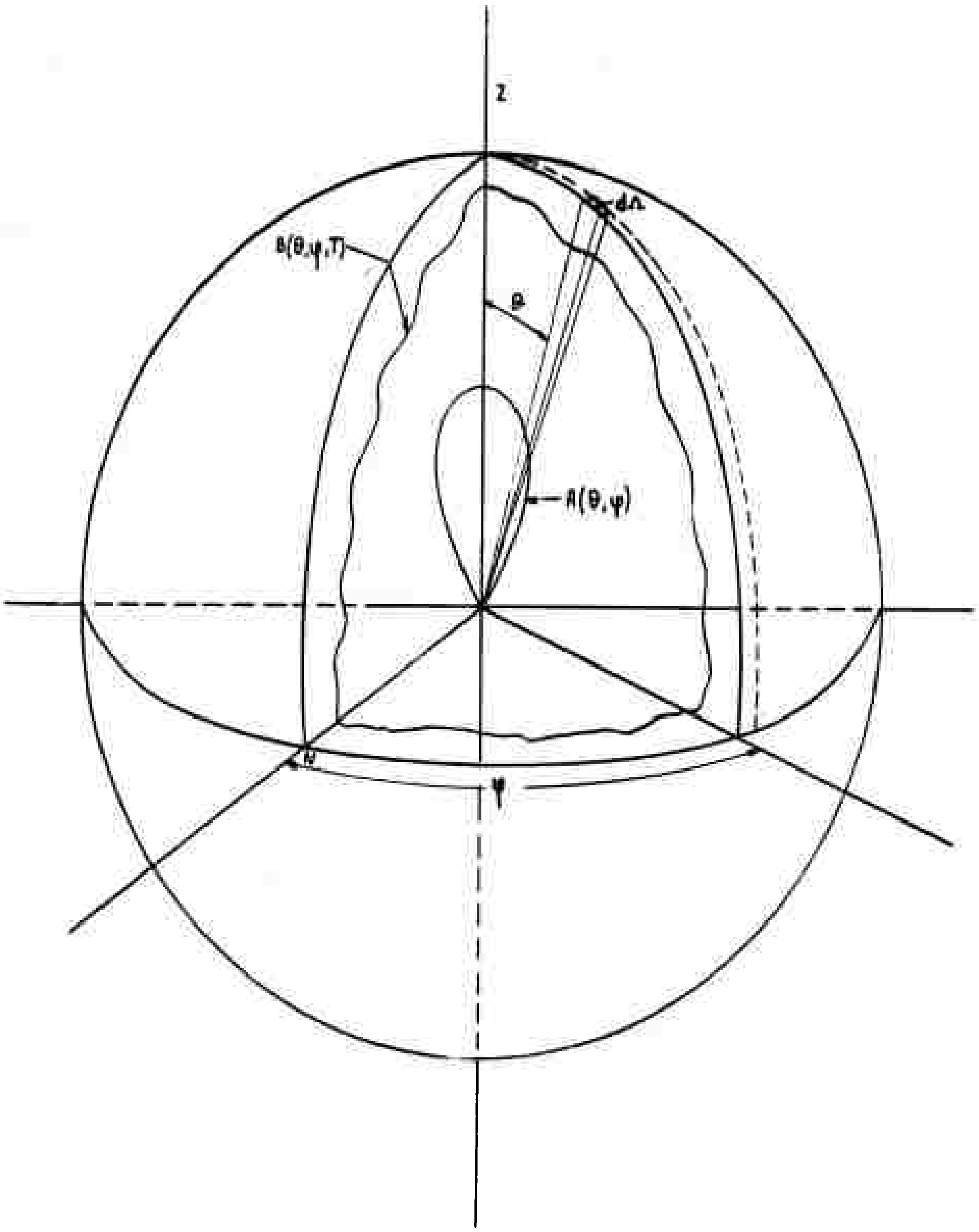

Fig. 1

where $k_1 = \frac{k}{\omega^2}$ and $D = \int_0^\infty N(h)\nu(h)\,dh$

It is to be noted that in general D is function of the local time, both N and ν are function of the zenith angle of the sun.

From relation (6) it appears that the received power depends on the antenna pattern and is a complicate function of both sidereal and solar time.

Accordingly the received noise presents a daily variation due to the apparent movement of the sky above the antenna as well as to absorption variations.

Since the sidereal hour gains about 4 minutes a day over the solar time, the same zone of the sky my be observed in different conditions of absorption.

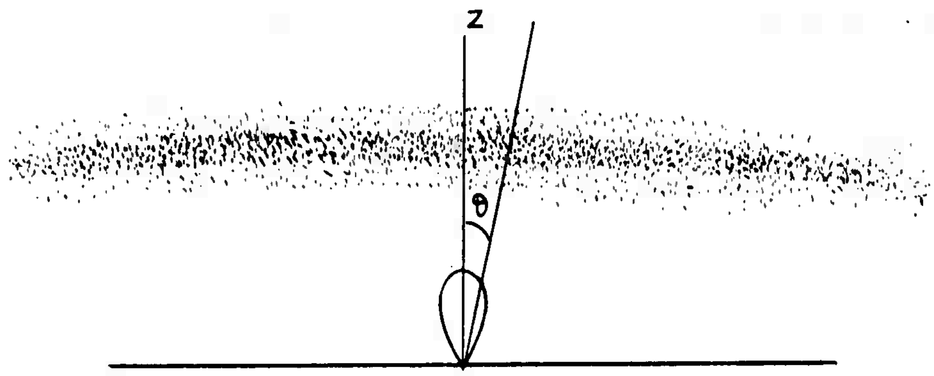

Fig. 2

In general the cosmic noise level corresponding to a given sideral time passes during a year through a maximum and a minimum.

The maximum value is taken as that one corresponding to vanishing absorption. It can be remarked that the fluctuations of the single sources are averaged on the antenna beam and that in particular the contribution of the quiet sun is negligible compared with the noise due to the sky since the angular extent of the sun is very narrow in respect to observed sky. Consequently the unattenuated cosmic noise power P_u turns out to be a periodic function of the time, whose period is equal to the sideral day.

With regard to the frequency employed for the measurements, we recall that the absorption coefficient is inversely proportional to the frequency. Accordingly, low operation frequencies correspond to large absorptions, which are easy to be measured. However at frequencies of the same order as those of the crossed layer, n_1 turns out to be different from 1, and the absorption becomes deviative. Further, the 'window' effect introduces an error in the values of the observed level as it is outlined in the sequel ([6]).

Let us consider an antenna receiving the cosmic noise arriving from the sky through the ionosphere. The antenna receives only the noise coming from a conical solid angle about the zenith, whose semiaperture α is given by

$$\sec\alpha = \frac{\omega}{\omega_0} \quad *$$

being ω_0 the critical frequency of the crossed layer.

---

* Since if the propagation path of the incoming cosmic waves makes an angle $\chi > \alpha$ with respect to the zenith, the cosmic waves will be reflected on the high regions of the ionosphere.

In this case a new function $B'(\theta,\varphi,T)$ must be used in Eq. (6) in order to take into account that the distribution of the radio sources will appear to be modified by the reflection of the cosmic radiowaves on the high ionospheric regions.

Variations of N correspond to variations of the absorption coefficient but also to variations of ω_0; consequently α varies when N varies. Now the variations of α give effects analogous to the variations of the absorption coefficient, so that an error may arise in evaluating the absorption itself. In order to eliminate this cause of error, the variations of α must be indipendently evaluated, for example, by means of ionosonde data ([6]). However, the best system would probably be to employ directive antennas, having the reception-cone aperture narrower than the minimum angular aperture of the window.

3 - Eclipse Effect

During an eclipse the decay of the electron density in the shadowed zone produces a window of smaller attenuation in the ionosphere. Accordingly the ionospheric absorption decreases, and one can measure the change of absorption with respect to the normal day. Of course, when the measurements are performed on the cosmic noise level the decrease of the absorption is due to the integral effect of the electron density decay in the ionosphere as a whole.

The cosmic noise method does not seem to be frequently applied during eclipses ([7]).

In general the variation of the absorption follows the eclipse with a delay due to the time of recombination. In addition it is to be noted that the decrease of the absorption may be affected by variations of the collision frequency during the eclipse.

4 - Eclipse Geometry

The circumstances of the solar eclipse of 15 February 1961 over Italy are given in Fig. 3 where the line 0 indicates the path of the totality (central line) at the ground; the other heavy lines indicate the path of the totality at the various ionospheric levels projected on the ground. In the same figure the times of greatest phase along the path of the eclipse are also shown.*

From the map of Fig. 3 it appears that in the observation place (Florence 43° 48' lat. N, 11° 14' long. E) the eclipse was total at the ground, but was partial at the high ionospheric levels. This is due to the low altitude of the sun on the horizon plane (about 14°) during the eclipse.

The phases of the eclipse at Florence on the ground (Observatory of Arcetri) calculated by A. Kranjc ([8]), are given in the following table with the approximation of one second (all times are U.T.).

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* by courtesy of the 'Istituto Nazionale di Geofisica' of ROMA, Italy

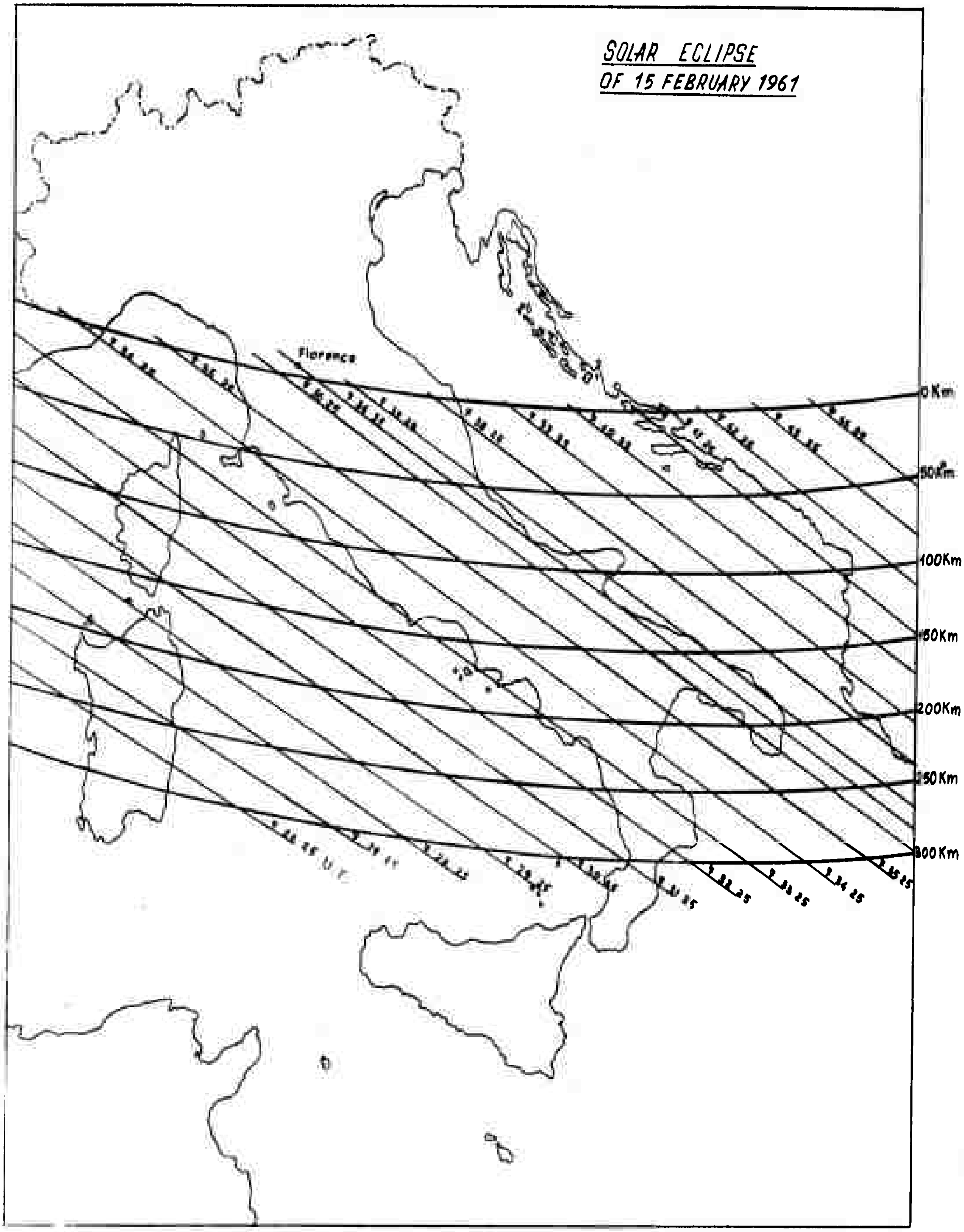

SOLAR ECLIPSE
OF 15 FEBRUARY 1961
Florence
0 Km
50 Km
100Km
150Km
200Km
250Km
300Km

Fig. 3

T A B L E I

Beginning of the eclipse (first contact)	$06^h\ 31^m\ 47^s$
Beginning of the totality (second contact)	$07^h\ 35^m\ 49^s$
Greatest phase	$07^h\ 36^m\ 52^s$
End of the totality (third contact)	$07^h\ 37^m\ 56^s$
End of the eclipse	$08^h\ 48^m\ 17^s$

5 - Equipment

Our first program was to perform simultaneous measurements in the totally shadowed zone of the ionosphere as well as in the penumbral ionospheric zone. To this purpose it would have been necessary to use a narrow beam antenna for the umbral zone and a low radiation angle antenna for the penumbral zone. However as soon as the geometry of the eclipse of 15 February 1961 was realized it clearly appears that, due to the low altitude of the axis of the shadow cone with respect to the plane of the horizon, it was impossible to accomplish such an experimental arrangement. Then we set up a more suitable experimental arrangment which will be described in the sequel.

Two riometers and a total power radiometer were used on 27.6 MHz. In addition two radiometers operating on 40 and

108 MHz were set up for the purpose of monitoring the cosmic noise level on these frequencies. The antennas to which the apparatuses were connected will be described in the following section.

The station of observation was placed in a zone far from town in order to avoid disturbances as much as possible.

5.1 - Antennas

All the employed antennas were directed towards the zenith. A three elements Yagi was connected to one of the two riometers: this antenna has a lobe $110^{\circ} \times 60^{\circ}$ wide and is of the type commonly used for riometers. A four turns helix, 12 m high, 3,6 m diameter, was used for the other riometer (Fig. 4). Measurements carried out on a model showed that such an antenna has a symmetric lobe $\sim 57^{\circ}$ wide.

The total power radiometer at 27.6 MHz was connected to another Yagi antenna of the same type used for the riometer.

The geometry of the three antennas with respect to the ionospheric regions totally eclipsed appears clearly from Figs. 5, 6, 7. Each of these figures shows sections of the antenna beam at various levels and the corresponding totally shadowed ionospheric region, both projected on the ground. It is to be noted that the aperture of the reception cone of the antennas was determined at 3 dB below the maximum. From the same figures it appears that a totally eclipsed part of the low ionosphere

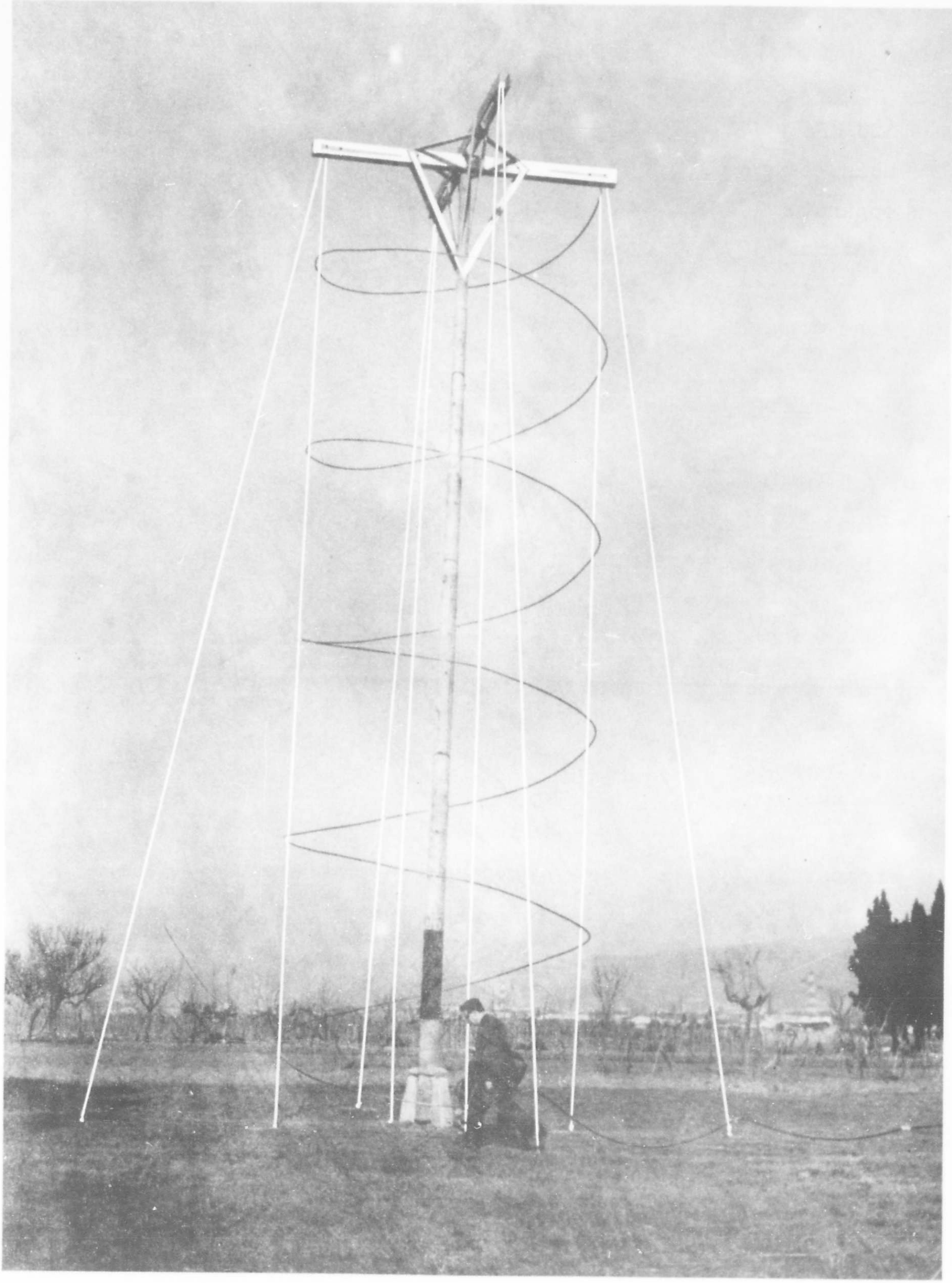


Fig. 4

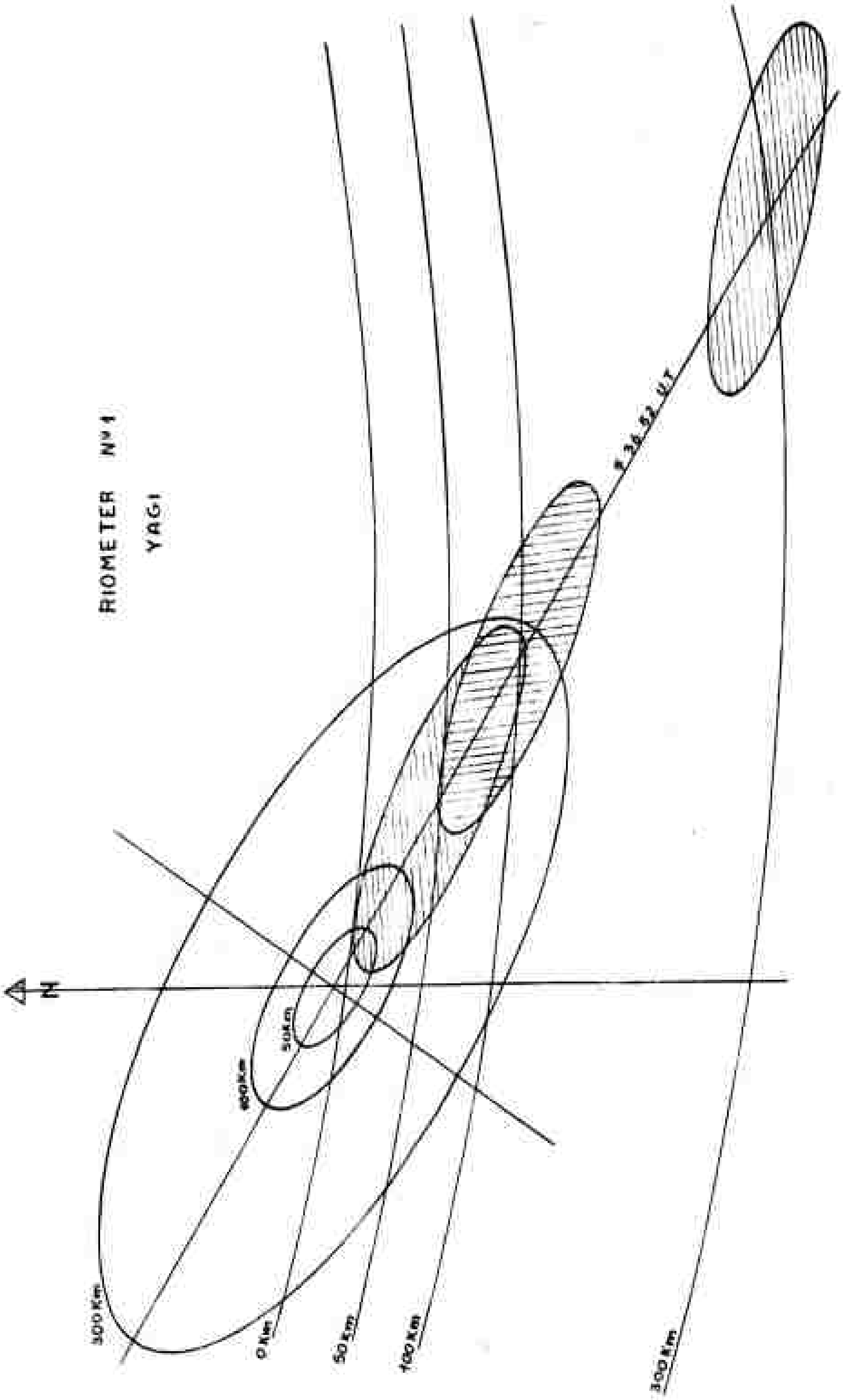

RIOMETER Nº1
YAGI
N
8 36 52 UT
50Km
100Km
300 Km
0 Km
50 Km
100 Km
300 Km

Fig. 5

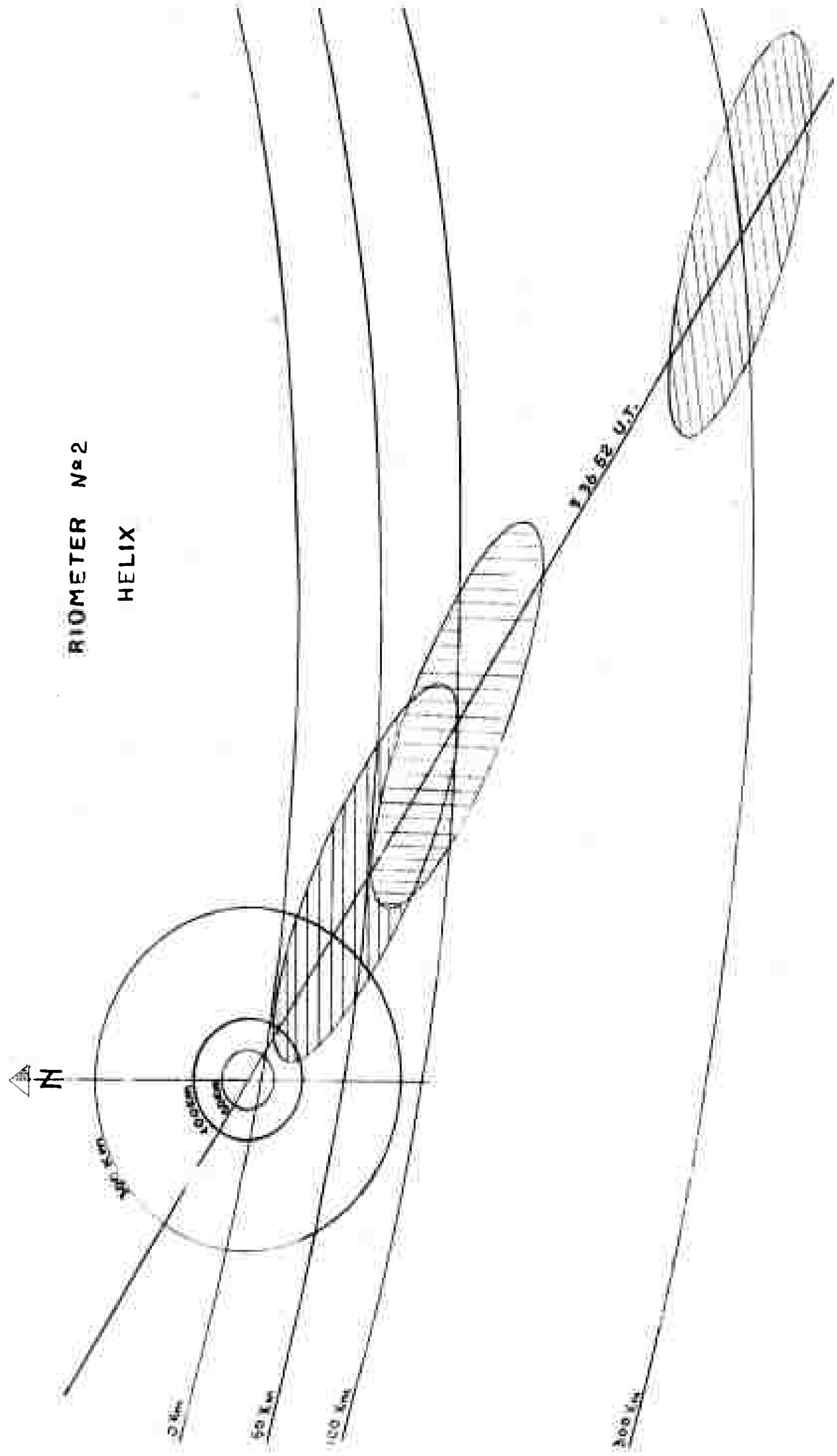


Fig. 6

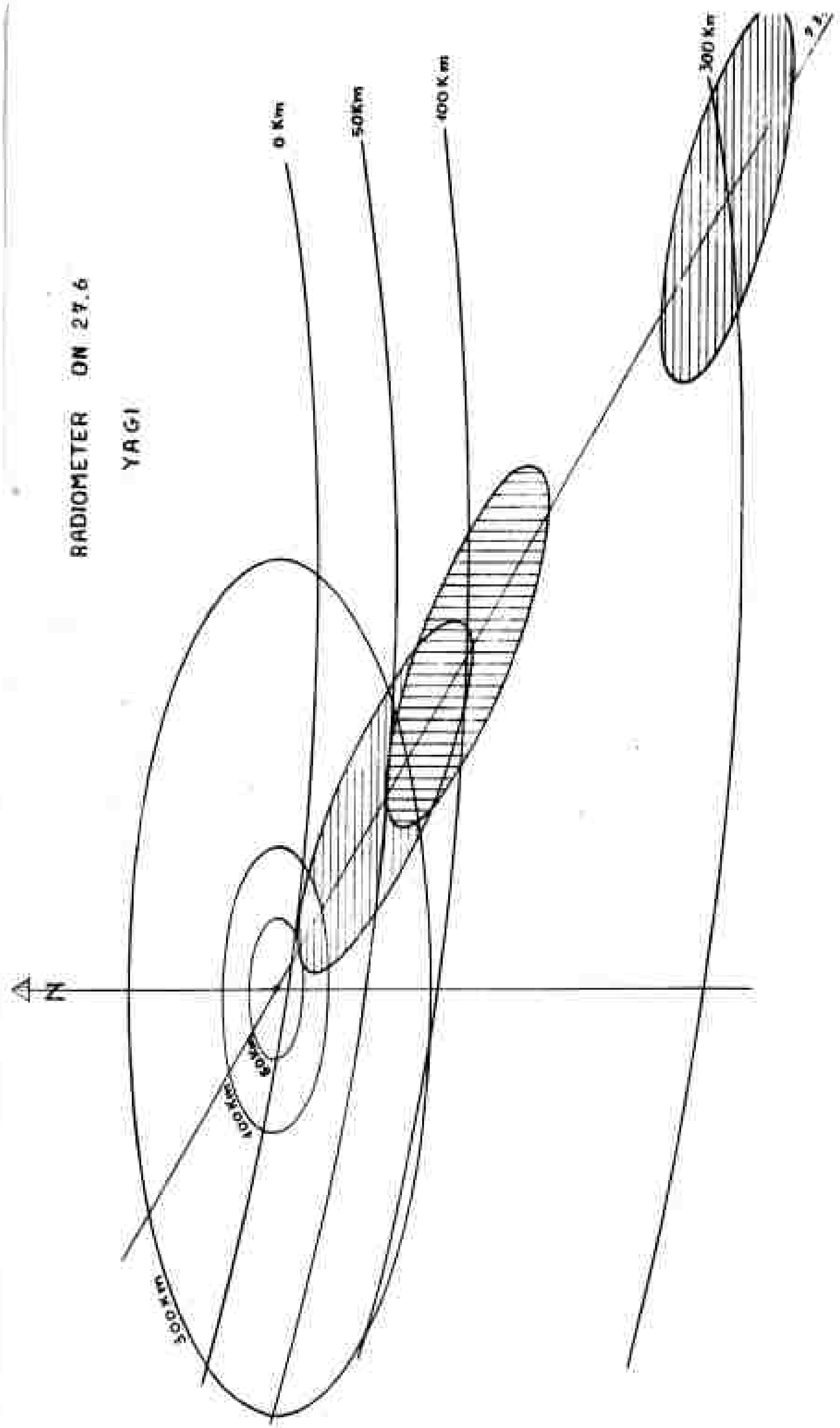


Fig. 7

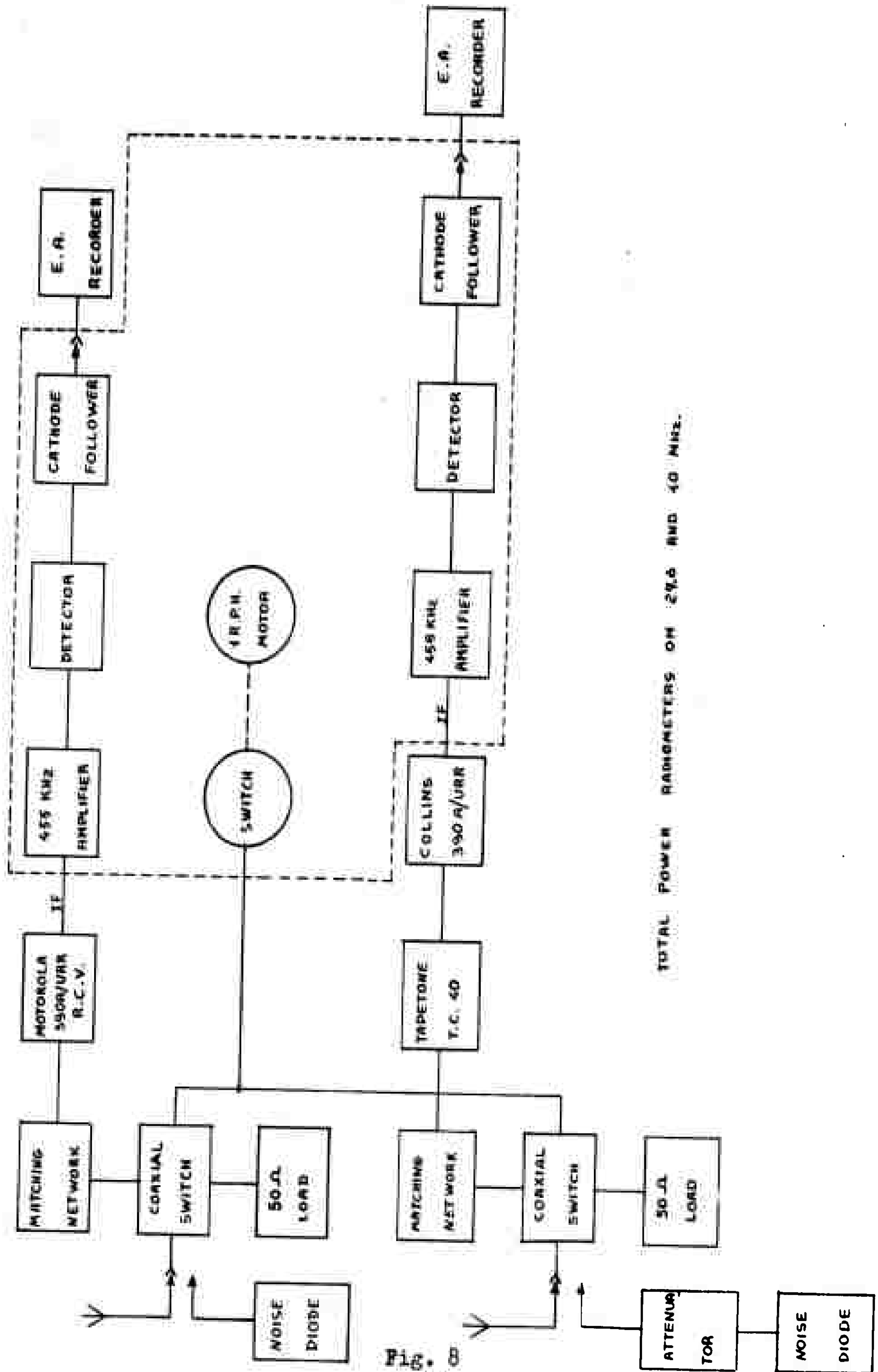
was seen by the antennas. The helix antenna observed a narrower part of the shadowed region and the umbra remained in the antenna beam for a smaller time. However the main part of the ionosphere observed by the antennas was partially eclipsed and the received cosmic noise was averaged by the antenna beams, although the noise recorded by the helix resulted less smoothed.

The radiometers at 40 and 108 MHz were connected respectively to a horizontal dipole oriented N-S and to a double four-element Yagi.

5.2 - The Riometers

It is well known that the riometer was introduced by Little in order to monitor the blackouts in the auroral zone during the IGY (9). This device is an automatic zero system by means of which the measurement of the incoming noise is carried out by equating it to a reference noise generated locally by a diode.

The system offers a very good long-term stability. The riometers we used have been furnished to us by the Norwegian Defence Research Establishment. Their characteristics are similar to those of the riometer by Little with the only exception that they have no frequency sweeping and minimum detector. Details on the norwegian riometers are given in (10).



TOTAL POWER RADIOMETERS ON 29.6 AND 40 MHz.

Fig. 8

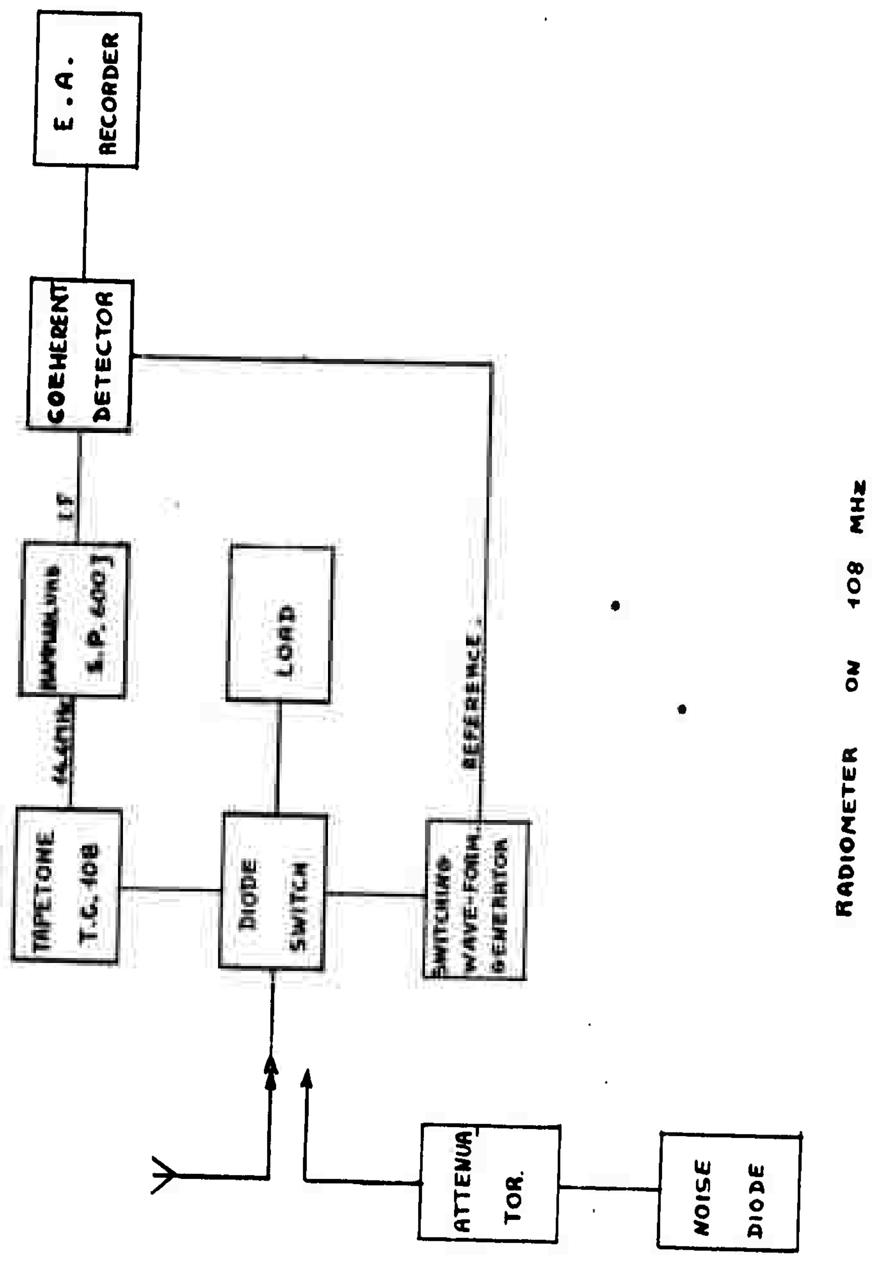

E.A. RECORDER
COHERENT DETECTOR
HAMMARLUND S.P. 600J
LF
TAPETONE T.C.108
DIODE SWITCH
LOAD
SWITCHING WAVE-FORM GENERATOR
REFERENCE
ATTENUATOR
NOISE DIODE
RADIOMETER ON 108 MHz

Fig. 9

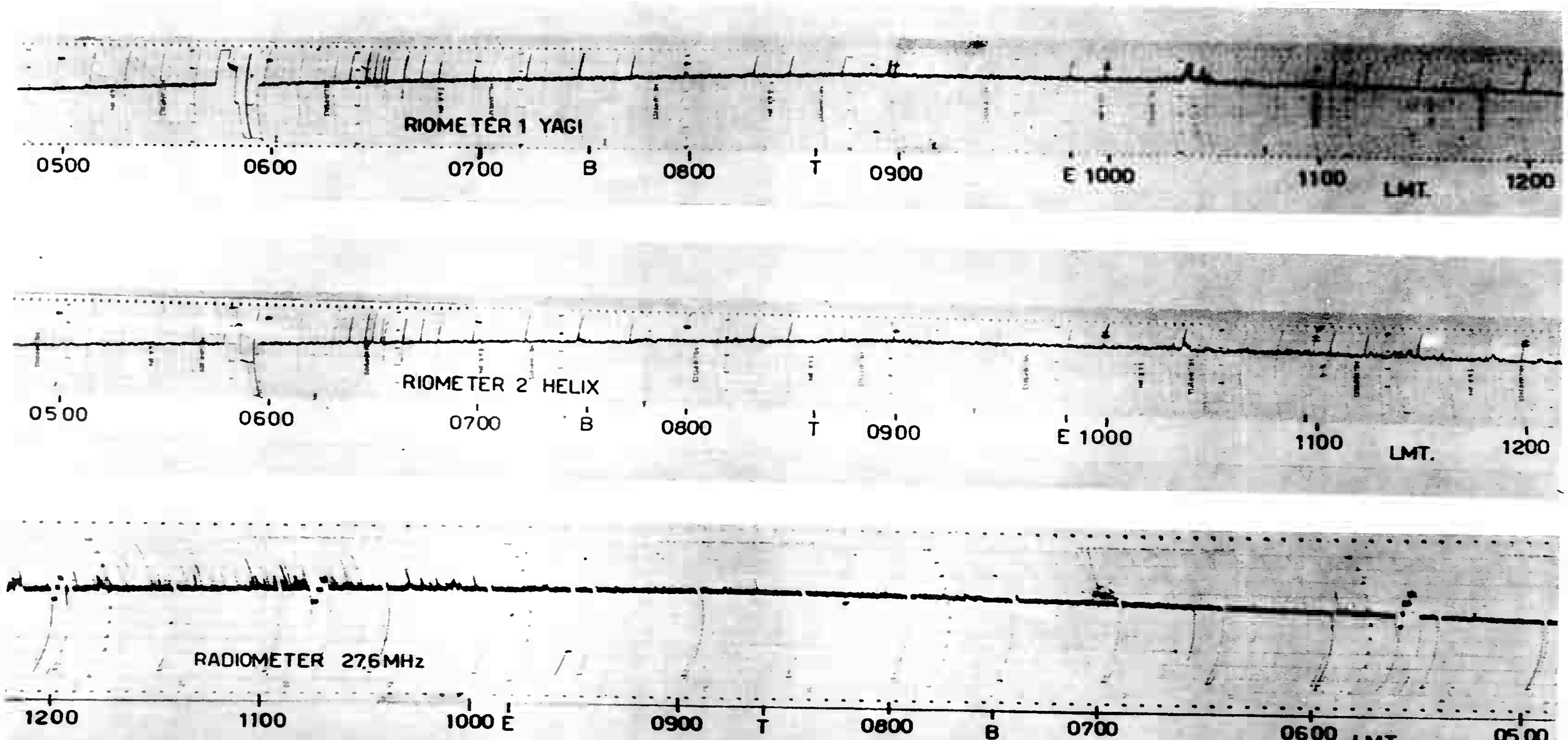

RIOMETER 1 YAGI
0500
0600
0700
B
0800
T
0900
E 1000
1100
LMT.
1200
RIOMETER 2 HELIX
0500
0600
0700
B
0800
T
0900
E 1000
1100
LMT.
1200
RADIOMETER 27.6MHz
1200
1100
1000 E
0900
T
0800
B
0700
0600
LMT.
0500

FIG.10

5.3 - The Radiometers

As noticed in section 5 two total power radiometers built at Centro Microonde were used on 40 and 27.6 MHz. Each of these apparatuses is composed by a receiver followed by a recording system which reads the outputnoise level of the receiver. The used band-width was 4 KHz. The calibration was carried out at interval of half an hour by means of a coaxial switch which connects the input of the receiver to a noise source or to a dead load. The block diagrams of the two total power radiometers are shown in Fig. 8.

Another radiometer was set up for the measurements on 108 MHz. This radiometer which is of the Dickie type, is composed by an antenna-switch of the diode-type followed by a converter TC 108 and by a Hammarlund receiver SP 600 J. The used band-width was 13 KHz; a syncronous detector measures the AF output of the Hammarlund, and the calibration is performed by means of a noise diode source. Fig. 9 shows the block diagram of this radiometer. The antenna system was pointed in such a way that the sun path remains in the lobe during the morning.

6 - Data Handling and Results

6.1 - Measurements on 27.6 MHz

Part of the records obtained during the eclipse day with the three apparatuses at 27.6 MHz is shown in Fig. 10. From the figure it appears that these records are free from inter-

ferences or disturbances.

In order to investigate the effect of the eclipse on the ionospheric absorption, the records at 27.6 MHz were analyzed using the following procedure.

Since it was expected that the variations of the cosmic noise level to be measured were very small, the reading of the records was performed at very short time intervals, namely every 2.5 minutes. Then a median curve was derived for each apparatus from the curves of the period 10th - 20th of February 1961 (except the 15th of the same month) by taking into account the variation of the sideral time.

It was assumed that these median curves which are plotted in Figs. 11, 12, 13, together with the respective curves recorded during the eclipse day, represent the 'normal day' curve of the 15th February. The received noise is referred in terms of noise diode current. The time marked BTE represents the beginning, the totality, and the end of the optical eclipse at the ground. The curves of Figs. 11, 12, 13, show a readable increase of the cosmic noise level during the eclipse compared with the 'normal day' curves.

To the aim of obtaining the decrease of the absorption during the eclipse the absorption variation between each control day and the eclipse day was evaluated for the three apparatuses at 27.6 MHz. From these curves a median curve was derived for each apparatus. The absorption variation plotted versus the universal time is shown in Figs. 14, 15, 16.

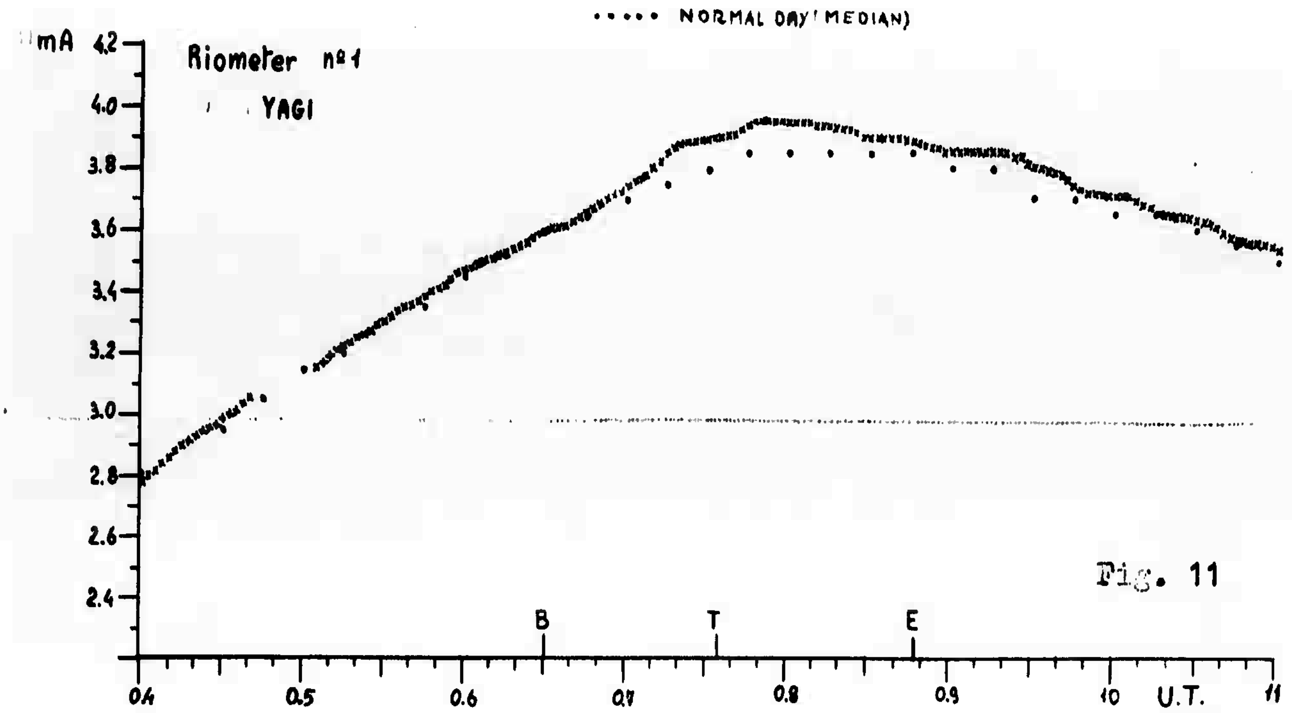


Fig. 11

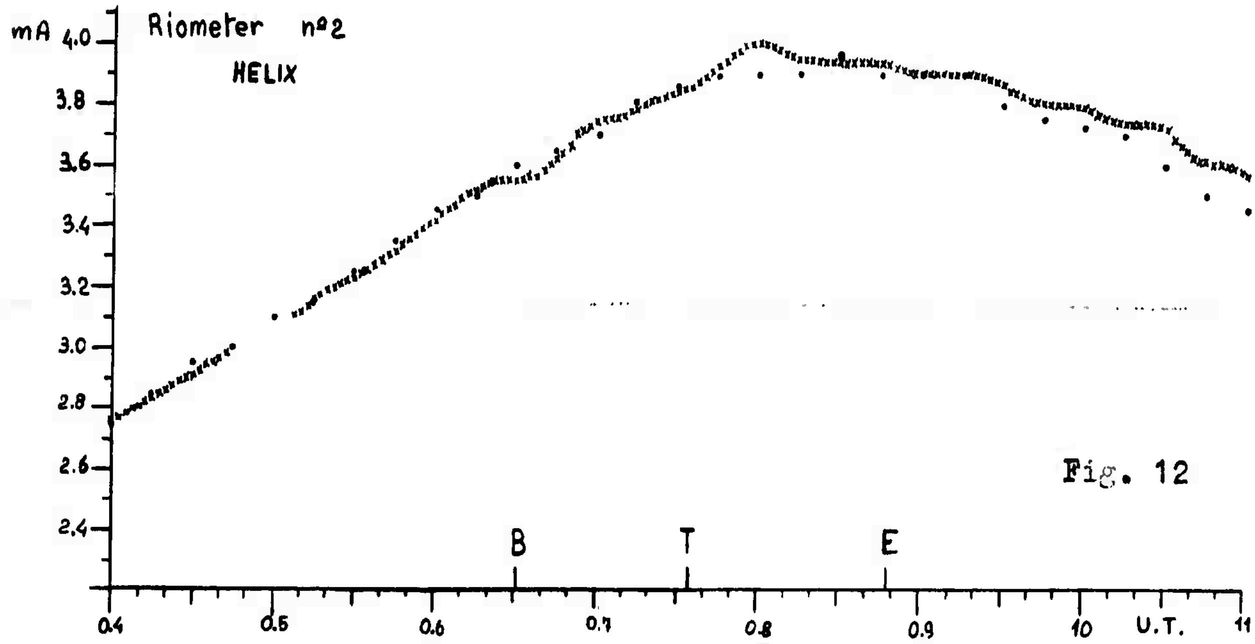


Fig. 12

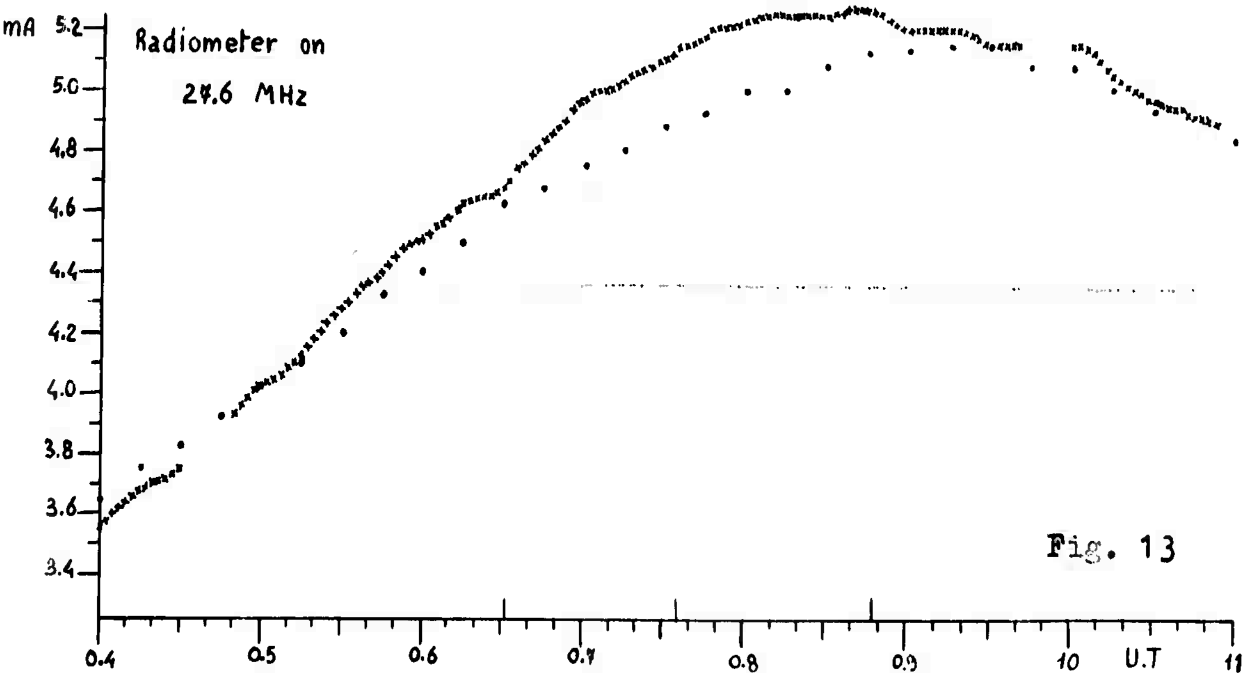


Fig. 13

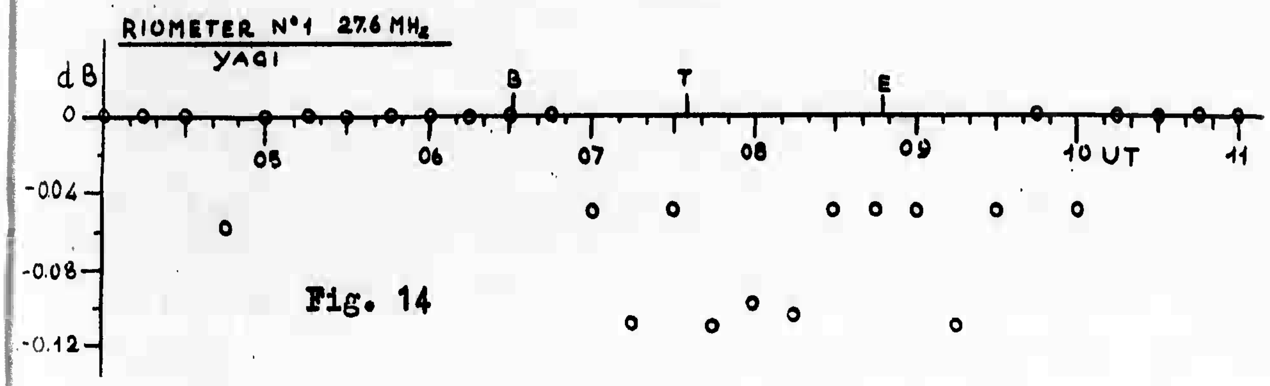


Fig. 14

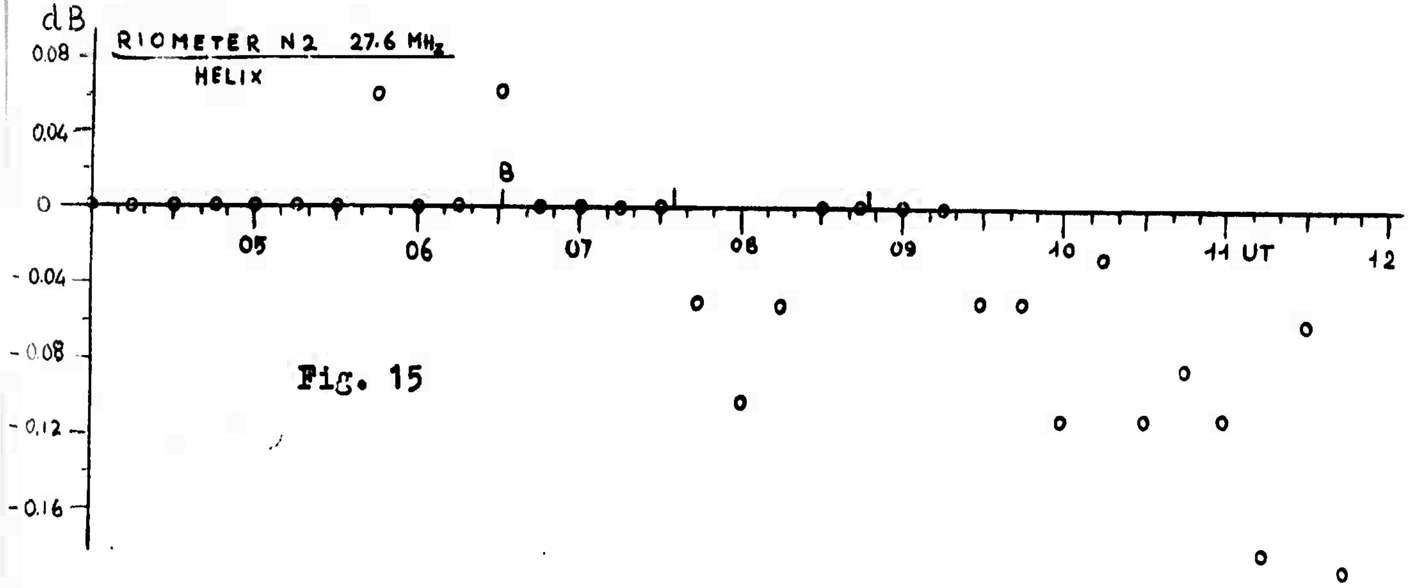


Fig. 15

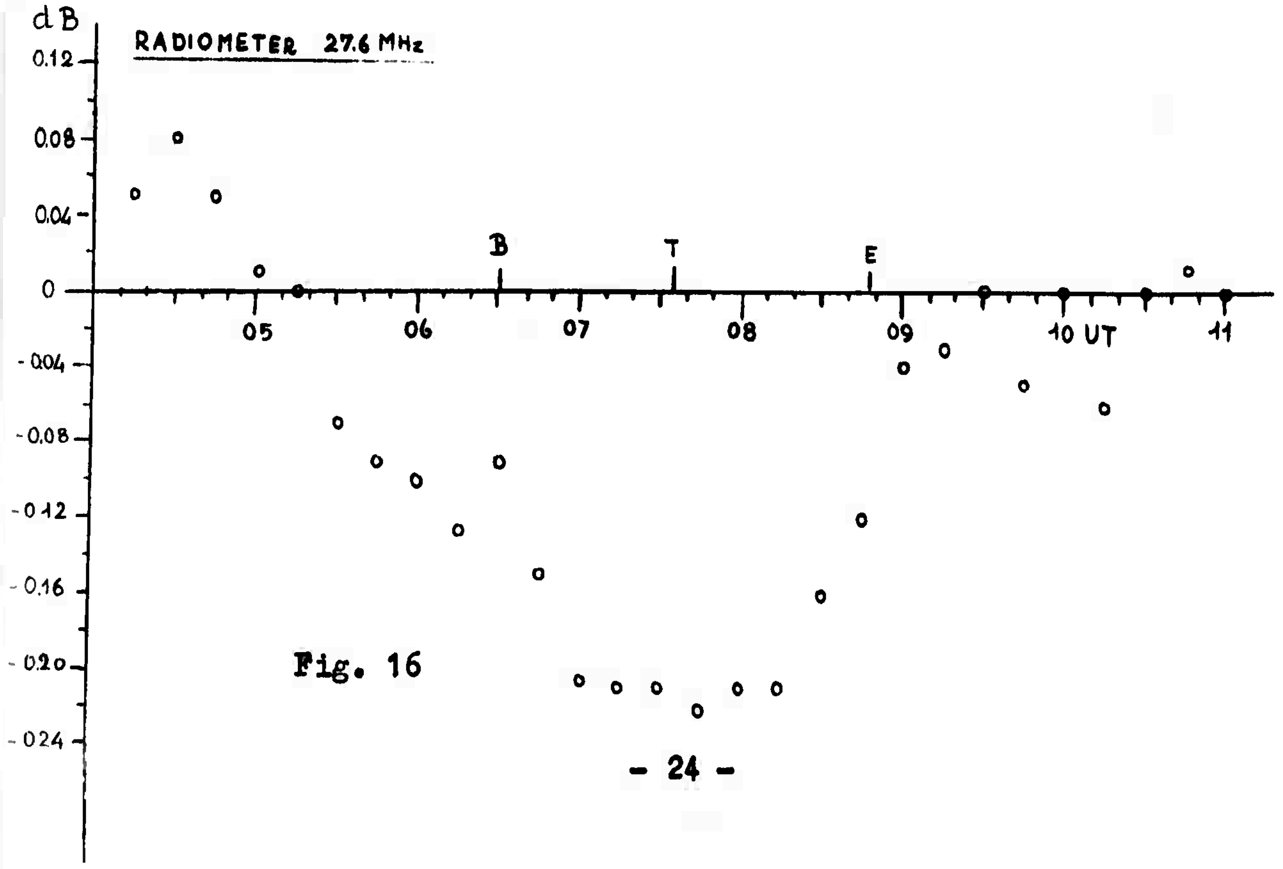


Fig. 16

The plot of Fig. 14 refers to the riometer connected to Yagi antenna: from this plot it appears that the absorption decrease becomes evident after 06.45 U.T., reaches the maximum of 0.11 dB between the 07.15 and 07.45 and returns to zero at 09.45. The delay between the maximum change of the absorption and the optical totality at the ground results about 8 minutes.

The plot of Fig. 15 refers to the riometer connected to helix antenna. The curve shows a rapid variation in the absorption between 07.30 and 08.30. The maximum decrease of 0.1 dB occurs at 08.00 with a delay of about 23 minutes with respect to the optical totality at the ground. A further variation in the absorption can be noted after 09.15.

Finally the plot of Fig. 16, related to the radiometer at 27.6 MHz, shows a readable variation of the absorption lasting from 06.30 to 09.00. The maximum change, 0.22 dB occurs at 07.45 namely about 8 minutes after the optical totality at the ground. Between 09.30 and 10.30 a second little decrease seems to happen.

6.2 - Measurements on 40 and 108 MHz

The radiometers on 40 and 108 MHz were kept operating from 13th to 18th and from 15th to 19th of February 1961, respectively. From the obtained records, excluding the records of 15th February, the 'normal day' curves were derived with the same method employed for the apparatuses on 27.6 MHz. Precisely for obtaining the median curves the following days were used: 13th,

14th, 16th, and 18th February for the radiometer at 40 MHz and 16th, 17th, 18th, and 19th of February for the radiometer at 108 MHz. On 40 MHz the record of 17th was avoided due to disturbances.

The median curves on 40 and 108 MHz are shown in Figs. 17, 18, together with the curves obtained on the eclipse day. The received noise is referred in terms of the scale of the attenuator used for the calibration.

On 40 MHz for a great extent in the eclipse day the cosmic level is higher than the level of the normal day; on the other hand the behavior of the two curves during the eclipse period, is rather similar. On the contrary on 108 MHz the curve of the eclipse is lower than the normal day curve in the early morning and becomes rather close to the normal day curve after 08.30 U.T.

In order to examine in detail the behavior of the cosmic noise level during the eclipse day on the frequencies 40 and 108 MHz, the variations between the level recorded on each control day and that one recorded during the eclipse were evaluated. Then from the obtained data a median curve was derived on both 40 and 108 MHz (see Figs. 19 and 20).

Fig. 19 refers to the radiometer on 40 MHz. The curve shows a maximum variation of 0.8 dB at 06.00 U.T. However no particular change can be noted during the eclipse period.

Fig. 20 which refers to the radiometer on 108 MHz shows some fluctuations but does not show any particular behavior during the eclipse.

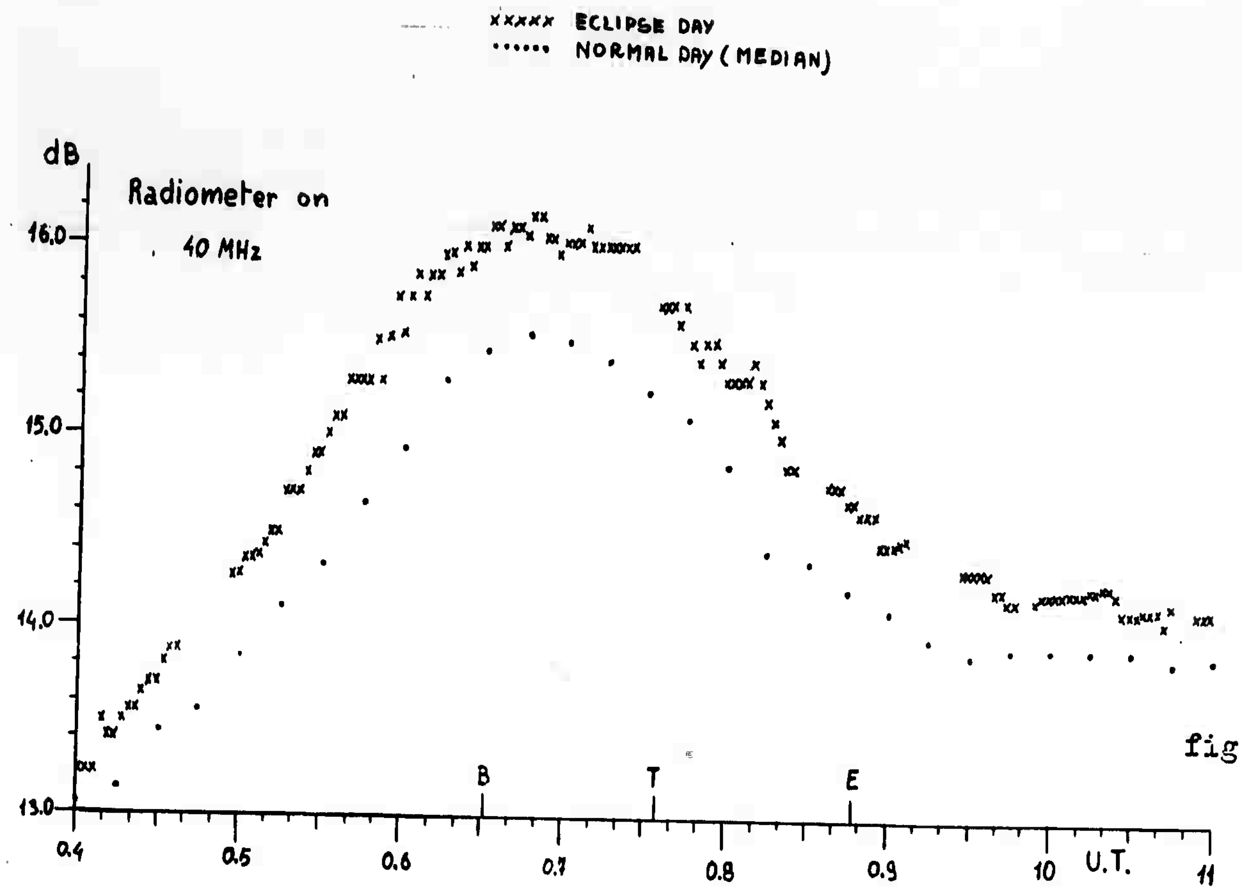

xxxxx ECLIPSE DAY
...... NORMAL DAY (MEDIAN)
dB
Radiometer on
40 MHz
16.0
15.0
14.0
13.0
B
T
E
0.4
0.5
0.6
0.7
0.8
0.9
10
U.T.
11

fig. 17

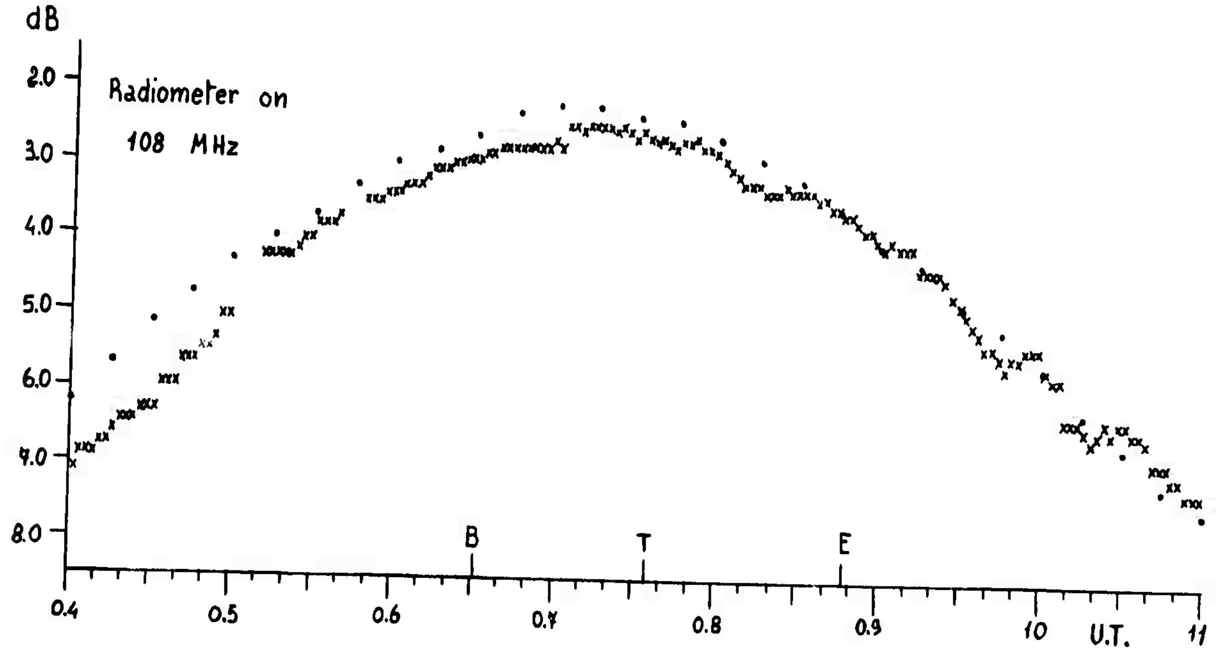

dB
Radiometer on
108 MHz
2.0
3.0
4.0
5.0
6.0
7.0
8.0
B
T
E
0.4
0.5
0.6
0.7
0.8
0.9
10
U.T.
11

fig. 18

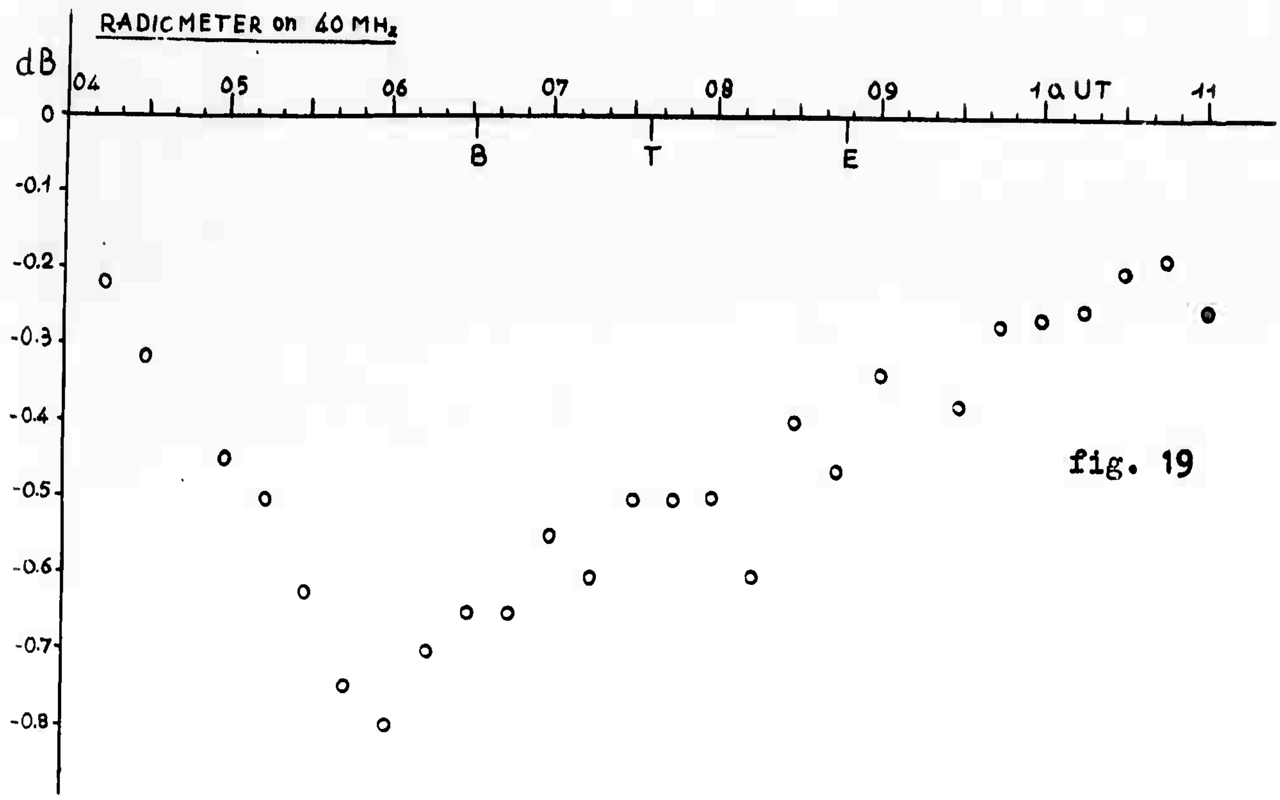

RADIOMETER on 40 MHz
dB
04
05
06
07
08
09
10 UT
11
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
B
T
E

fig. 19

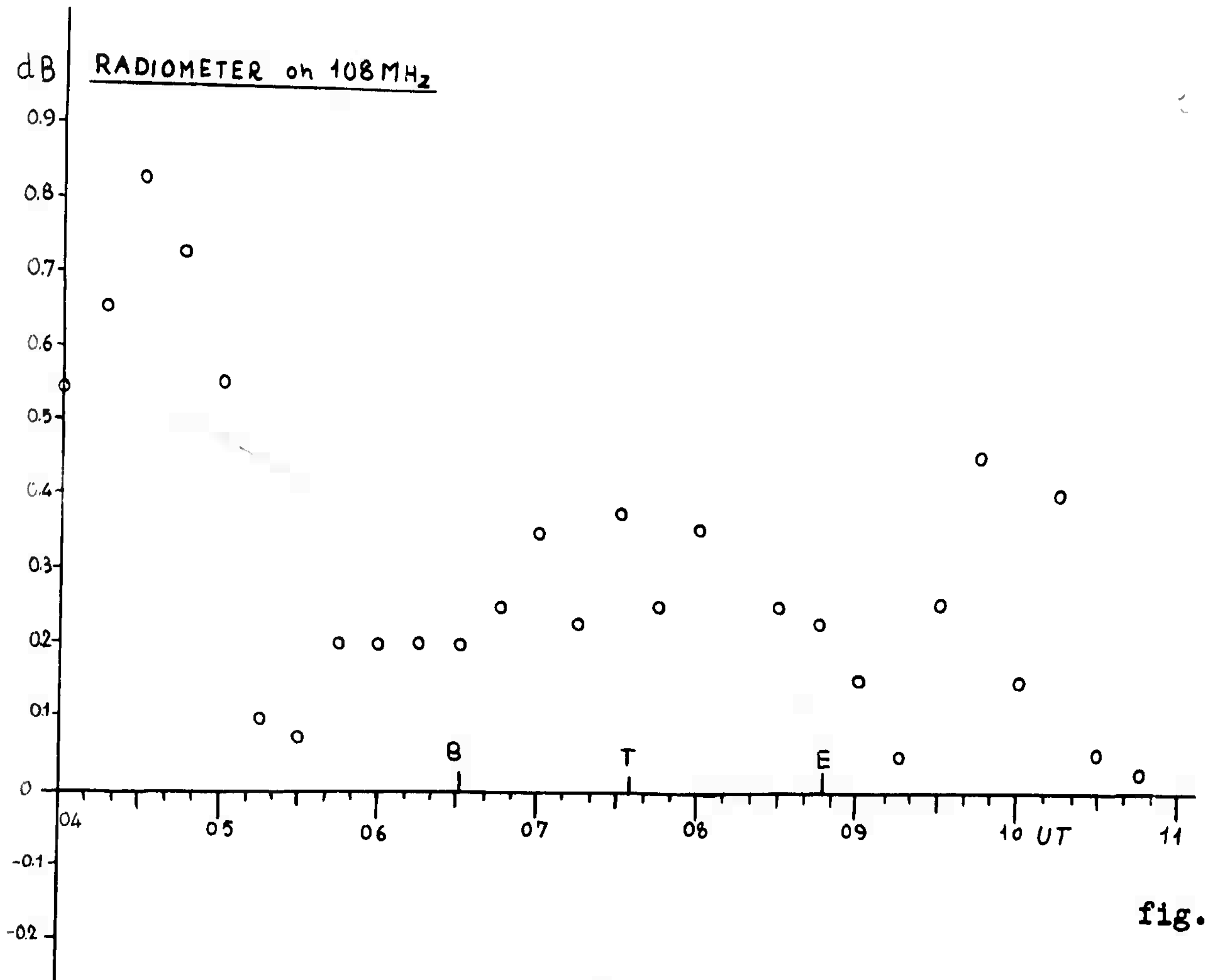

dB
RADIOMETER on 108 MHz
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
B
T
E
04
05
06
07
08
09
10 UT
11

fig. 20

7. Discussion of the Results

7.1 Observations on 27.6 MHz

As it was to be expected, the eclipse caused a small but detectable variation in the ionospheric absorption on 27.6MHz. The maximum change is about 0.1 dB for the riometers, 0.2 dB for the radiometers. It is to be remarked that at the employed frequency the normal absorption itself is low and that the eclipse happened immediately after the surise, when the ionization was weak, and in addition it was partial at the ionospheric level.

With regard to the delay between the optical totality and the maximum change of the absorption we must note that the optical totality is not well defined in the antenna beam. This is due to the large beam of the antenna and to the altitude range responsible for the absorption; therefore we will refer to the optical totality at the ground. We will only note that if one refers to the time of maximum coverage of the antenna beams, by the totally eclipsed region (at 50 km of altitude), the delay times found in sec. 6.1 increase of about 1 minute.

Of course the delay times we observed are to be regarded as mean values, since the received cosmic noise is averaged by the antennas.

The apparatuses connected to Yagi antennas, namely the riometer and the radiometer on 27.6 MHz, give about the same delay time of 8 minutes. This value may indicate that the variation of the absorption observed by these two apparatuses took

place mainly in the low ionosphere where the deionization is rapid ([11]).

The absorption variation, detected by the radiometer, lasts a time longer than that of the riometer, and the respective values of the maximum change are one the double of the other one.

By recalling the position of the antenna beams with respect to the shadowed region at 50 km (Fig. 5, 7) and the different orientation of the two Yagi antennas, one can observe that the umbral zone remains in the beam of the radiometer antenna for a rather longer time, namely $\sim 2^m\ 29^s$ instead of $\sim 2^m\ 17^s$.

This fact may explicate the delay time observed as well as the difference in the durations of the observed phenomena and in the maximum change.

As already noted (sec. 6.1) the riometer connected to helix antenna shows successive variations in the absorption. The first of them, lasting a rather brief time, namely 1 hour, shows a maximum change of 0.1 dB and a delay time of about 23 minutes. This value and the general trent of the data given by the helix seem to correspond to a phenomenon arising in the higher ionospheric region where the deionization is slow and complicate phenomena due to the ionization gradients occur ([11]) ([12]).

This could be explained by the fact that, the helix antenna (Fig. 6) observed mainly partially shadowed zones of the ionosphere.

7.2 - Observation on 40 MHz and 108 MHz

On 40 MHz the cosmic noise level during a great part of the eclipse day is higher than the level of the normal day but does not show particular change during the eclipse period. More precisely from Fig. 19 it appears that the maximum variation in the cosmic level occurs before the first contact.

On 108 MHz the cosmic level in the early morning of the eclipse day is lower than the level of the normal day, but does not show particular behavior during the eclipse.

Since on 40 and 108 MHz the ionospheric absorption is negligible, the results obtained with these frequencies confirm that the increase of the cosmic noise level observed during the eclipse on 27.6 MHz is effectively due to the effect of the eclipse itself on the ionosphere.

7.3 - Particular Remarks

We would point out a particular observation on 40 MHz. In the afternoon of February 14th at about the same time at which a flare occurred on the sun ([13]), the records at 40 MHz clearly showed a sudden increase in the cosmic level; the main part of the phenomenon lasts about 1 hour (see Fig. 21). However on 27.6 and 108 MHz no variation in the cosmic noise level was observed.

Since during the eclipse day some flares occurred, particular attention was directed in order to check if the records

on 27.6, 40 and 108 MHz detected the eventual radio emission related to the same flares.

This analysis showed that our records of the 15th Febtruary were not affected by the flare. In particular the records on 27.6 MHz do not show any burst of the signal or disturbances during the eclipse period.

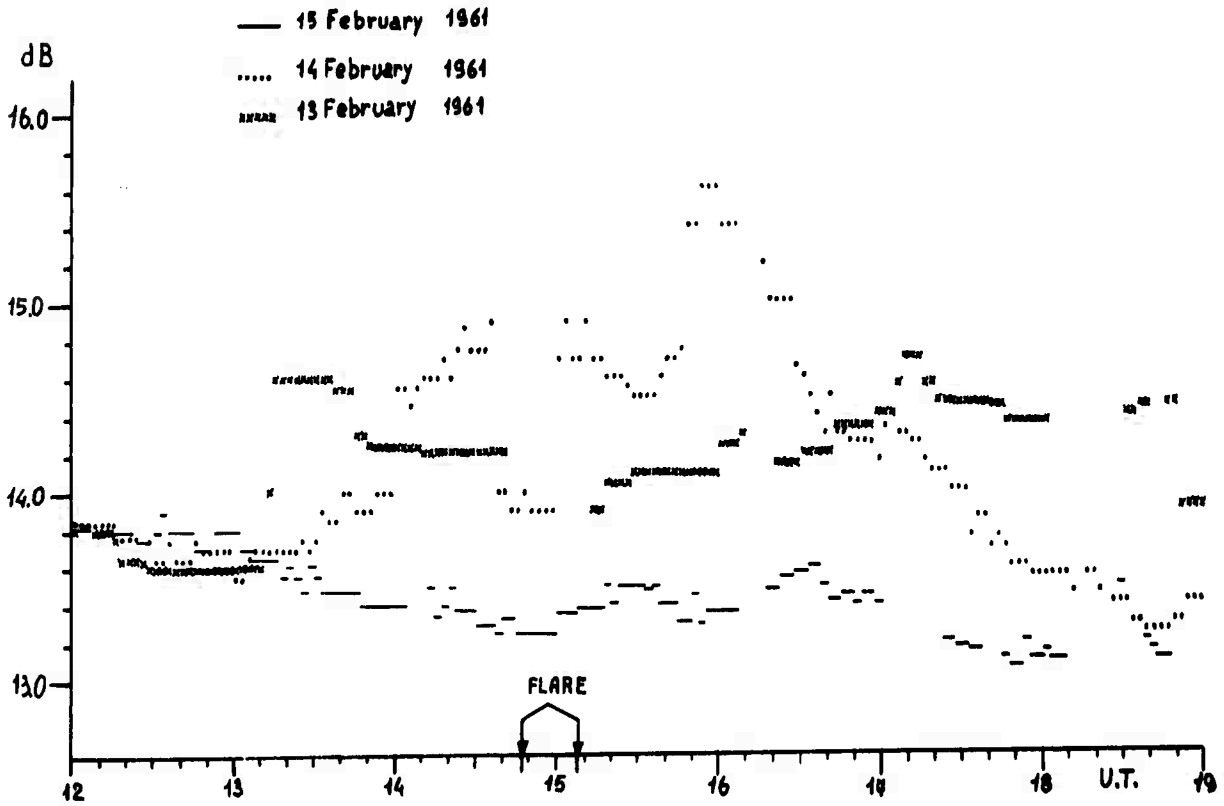


fig. 21

8. - Conclusion

The investigation we carried out reveals a detectable change in the ionospheric absorption on 27.6 MHz during the eclipse of 15th February 1961.

The obtained results may be explained in terms of a contribution to the phenomenon arising from the whole ionosphere.

The complex geometry of the present eclipse does not allow to derive further information from the cosmic noise absorption. However the method seems to be a promising one. The most suitable conditions for these kinds of measurements would happen during an eclipse occurring when the sun is near to the zenith of the place of observation.

In this condition the value of the absorption will be higher and the optical totality on the various ionospheric levels will occur about the same time.

Therefore from the absorption variation it would be perhaps possible to discriminate the contribution due to the low ionospheric region from the contribution of the high part of the ionosphere since their characteristic delay times are quite different.

The use of the directive antennas would allow the phenomenon to be more marked. However using directive antennas the fluctuations due to scintillation of the single sources become observable, while, with wide-lobe antennas, the fluctuations are

averaged by the antenna itself.

Frequencies lower than those we used may offer some advantages, since the absorption is stronger, and consequently it may be measured more easily. However highly directive antennas must be used in order to avoid the 'window effect'.

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Bibliography

(1) N. CARRARA, P.F. CHECCACCI, M.T. de GIORGIO: 'First Results Obtained During the Solar Eclipse of 15 February 1961, on the Cosmic Noise Absorption' - presented at the 6° AGARD Ionospheric Research Committee Meeting Naples, Italy (May 1961)

(2) E.V. APPLETON, W.R. PIGGOTT: 'Ionospheric Absorption Measurements during a Sunspot Cycle' - J. Atmos. Terr. Phys., 5, 141 (1954)

(3) K.A. SARADA, A.P. MITRA: 'Measurement of Cosmic Noise Absorption at Delhi on 22.4 Mc/s' - 'Some Ionospheric Results Obtained During the International Geophysical Year', W.J.G. Beynon ed. p. 270 (Brussels 1959); B. LUSIGNAN: 'Cosmic Noise Absorption Measurement' - J. Atmos. Terr. Phys. 23, 126 (1961)

(4) A.P. MITRA, C.A. SHAIN: 'The Measurement of Ionospheric Absorption, Using Observations of 18.3 Mc/s Cosmic Radio Noise' - J. Atmos. Terr. Phys. 4, 204 (1953); C.G. LITTLE, H. LEINBACH: 'Some Measurements of High-Latitude Ionosheric Absorption Using Extraterrestrial Radio Waves' - PROC.I.R.E., 46, 334 (1959)

(5) J.D. KRAUS, H.C. KO: 'Celestial Radio Radiation' - Scientific Report No. 1 Contract AF19(604)-1591 - The Ohio State University (May 1957)

(6) W.R. STEIGER, J.W. WARWICK: 'Observations of Cosmic Radio Noise at 18 Mc/s in Hawaii' - J. Geophys. Research, 66, 57 (1961)

(7) B. LANDMARK: 'Ionospheric Measurements in Norway During the Total Solar Eclipse of 30 June 1954'; K. RAWER: 'Absorption Measurements for the Eclipse of 30 June 1954'; W.R. PIGGOTT: 'Absorption Measurements During an Eclipse'- 'Solar Eclipses and the Ionosphere', W.J. Benyon, G.M. Brown ed., Pergamon Press; London (1956), p.54, 102,106.

(8) A. KRANJC: 'Astronomical Data for the Solar Eclipse 15 February 1961'- Centro di Studio per l'Astrofisica del C.N.R. - (Bologna 1960), A. KRANJC: 'Coelum' vol.28 p.105 ed. Associazione Astrofili Bolognesi Osservatorio Astronomico di Bologna (1960)

(9) C.G. LITTLE, H. LEINBACH: 'The Riometer - A Device for Continuous Measurement of Ionospheric Absorption' - PROC.I.R.E., 47, 315 (1959)

(10) B. BJELLAND: 'An Equipment for Measurement of the Galactic Noise Level for a Study of Ionospheric Absorption' - Intern. Rapport T-214 - Norwegian Defence Research Establishment (1961)

(11) K. RAWER: 'The Ionosphere', Federick Ungar Publ., 1st ed., p.87 (New York, 1956)

(12) K. DAVIES: 'Ionospheric Observations in Canada During the Solar Eclipse of 30 June 1954' - 'Solar Eclipses and the Ionosphere', W.J.G. Beynon, G.M. Brown ed., Pergamon Press, London (1956), p. 40

(13) 'Solar Geophysical Data' - Abstracted from CRPL-F Part B,p. IIIa, NBS, Central Radio Propagation Laboratory (March 1961)

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